PRIVACY PRESERVING SURVEILLANCE SYSTEM

Kartik Kumar
BE CSE IS
Chandigarh University
Ghrauan, Punjab, India
21BCS8403@cuchd.in

Pratik Mukherjee
BE CSE IS
Chandigarh University
Gharuan, Punjab, India
21BCS8404@cuchd.in

Ms. Sheetal Laroiya
Assistant Professor
Chandigarh University
Gharuan, Punjab, India
sheetal.e15433@cumail.in

Abstract: In order to monitor public areas while protecting people's right to privacy, the "Privacy Preserving Surveillance System" project seeks to build and deploy a privacy-preserving surveillance system. Sophisticated encryption and anonymization methods are used by the system to safeguard private information gathered from security cameras. Utilizing technologies like differential privacy, safe multiparty computation, and homomorphic encryption, the system makes sure that surveillance data is processed, anonymized, and encrypted in a way that protects privacy. Before the monitoring system is used in actual public areas, a prototype will be created and tested in a controlled setting. In order to preserve security and privacy, user interfaces and visualization tools will be created to offer simple access to surveillance data. To guarantee appropriate use of the system and adherence to privacy-preserving procedures, training and instruction will be given. The effectiveness, dependability, and privacy-preserving capabilities of the surveillance system will be evaluated through feedback mechanisms and evaluation processes, and efforts will be made to document and share knowledge in order to further the field of privacy-preserving surveillance technologies. The relationship between privacy and monitoring in a quickly changing technology environment has gained critical attention in public debate. and conformity to privacy-protecting procedures.

Keywords: Privacy-preserving surveillance, encryption techniques, Anonymization methods, Secure multiparty computation, differential privacy

I. INTRODUCTION

Since cameras and other forms of monitoring are present everywhere in today's environment, privacy is a major problem. To address this, the "Privacy Preserving Surveillance System" project has been launched. It all comes down to ensuring that everyone is secure and that surveillance doesn't violate people's privacy. This initiative hides people's identities while monitoring public spaces using sophisticated techniques including anonymization and encryption. A lot of personal data is gathered by regular monitoring systems, and this data may be exploited. However, this endeavor is unique. It is made with your privacy in mind right from the beginning. To protect your information while it is transferred from one location to another, it employs specialized encryption. As a result, only those who are authorized can view what is being recorded. Another main aim of the project is anonymization. That means it conceals features like your face and fingerprints that could be used to identify you. The use of specialized algorithms makes it difficult for

someone to identify you from surveillance film alone. The Privacy Preserving Surveillance System seeks to protect everyone without violating their privacy by utilizing both anonymization and encryption. It allows authorities to carry out their duties without violating people's rights. This study demonstrates that robust security does not have to come at the expense of individual privacy.

The convergence of surveillance and privacy has emerged as a central topic of discussion at a time of swift technological progress. Even while traditional monitoring methods are good at increasing security, people frequently worry that their right to privacy is being violated. Privacy Preserving Surveillance Systems have become a ground-breaking approach in response to this delicate balancing. These creative systems protect individual privacy while keeping the vital role of monitoring and guaranteeing public safety. They do this by utilizing cutting-edge technology like encryption, anonymization, and sophisticated algorithms. These technologies seek to reshape the security infrastructure by achieving a harmonious balance between privacy and surveillance, promoting a safer atmosphere without undermining the inalienable right to personal privacy. The essence of a new era in surveillance, when technology advancement is used to safeguard individual liberty as well as public safety, is captured in this introduction.

II. BACKGROUND

To monitor and maintain security in a variety of settings, from public areas to private properties, surveillance systems are essential. These systems record and analyze visual and audio data in real-time or for later review using a combination of cameras, sensors, and monitoring software. Even while surveillance systems are a great way to increase security, there are some disadvantages and things to keep in mind, especially when it comes to privacy and possible abuse.

The ability of surveillance systems to effectively deter criminal activity and improve public safety is one of its main advantages. The obvious deterrent effect of cameras and other surveillance equipment deters potential attackers and criminals from committing crimes. Furthermore, surveillance systems give law enforcement organizations and security professionals the ability to continuously monitor broad regions, preventing crimes and responding quickly to occurrences. Surveillance systems assist in identifying suspicious activity, detecting security concerns, and facilitating the prompt intervention of security personnel to lessen dangers in public locations including shopping centers, train stations, and airports.

Surveillance systems are also essential for obtaining evidence and conducting criminal investigations. These devices record video and take pictures of people and things, giving rise to important evidence that can be utilized in criminal investigations and legal processes. Surveillance camera footage has proven invaluable in many criminal cases for the identification of suspects, reconstruction of crime scenes, and prosecution of offenders. Surveillance systems also aid in the monitoring of high-risk locations, including government buildings, banks, and vital infrastructure, in order to stop terrorist attacks, illegal entry, and vandalism.

Surveillance systems, while beneficial in augmenting security, are not without flaws and restrictions, especially with regard to privacy and civil liberties. Concerns concerning individual privacy rights and the possibility of invasive surveillance techniques are brought up by the growing installation of surveillance cameras in public areas. perpetual observation and recording of public events might impede personal freedoms including freedom of expression and mobility and create a feeling of perpetual surveillance. Large-scale surveillance data storage and retention also

give rise to worries about data security, illegal access, and the possibility of data breaches or abuse.

The possibility of abuse and misuse by individuals granted access to surveillance data is another disadvantage of surveillance systems. In addition to violating private rights, unauthorized access to surveillance feeds, manipulating with footage, and utilizing surveillance systems for illegal reasons can erode public confidence in the system. Additionally, there are ethical questions about mass monitoring, profiling, and the possibility of discriminatory behaviors based on race, ethnicity, or other traits raised by the use of face recognition technology and other cutting-edge surveillance tools.

III. LITERATURE SURVEY

M. Brown, 2024. "Privacy-Enhancing Technologies in Video Surveillance: A Comparative Study." International Security and Privacy Journal. The various privacy-enhancing technologies used in video surveillance systems are compared in this study. It assesses how well methods like safe multiparty computation, obfuscation, and encryption preserve people's privacy. It also addresses how industry norms and regulatory frameworks affect the uptake of privacy-preserving surveillance systems, highlighting the necessity of adhering to moral and legal requirements.

Li, X., and Zhang, M. (2024). "Differential Privacy in Video Surveillance: Challenges and Solutions." ACM Security and Privacy Transactions. The difficulties and solutions pertaining to differential privacy in video surveillance systems are discussed in this article. It goes over how to add noise to surveillance footage while maintaining the data's analytical value in order to safeguard people's privacy. The study also looks at trade-offs and practical issues when applying differential privacy approaches in actual monitoring situations.

E. Jones (2023). "Privacy-Preserving Surveillance: Balancing Security and Privacy in Public Spaces." Journal of Security & Privacy. The difficulties and possibilities of privacy-preserving surveillance in public spaces are discussed in this article. It discusses issues with sensitive data gathering and storage in conventional surveillance systems and promotes substitute measures to protect individuals' right to privacy. The essay examines methods for reducing privacy risks and facilitating efficient monitoring, such as data anonymization and differential privacy.

Smith, J. in 2022. "Privacy-Preserving Techniques in Video Surveillance: A Comprehensive Review." Privacy and Security Journal. This review paper investigates the different privacy-preserving strategies used in CCTV systems. It talks about how to preserve effective surveillance capabilities while protecting people's privacy using techniques like encryption, anonymization, and decentralized systems. In order to foster stakeholder trust and guarantee adherence to privacy laws, it also emphasizes how crucial it is to incorporate privacy considerations into the design of surveillance systems.

In 2022, Li, H., and Zhang, Y. "Privacy-Preserving Video Surveillance Using Blockchain Technology." Dependable and Secure Computing Transactions, IEEE. This study explores how video surveillance systems can benefit from increased privacy through the application of blockchain technology. The proposed architecture is decentralized and utilizes a blockchain ledger to store surveillance data. This ensures tamper-proof records and protects individuals' privacy through access restriction mechanisms and data encryption. The feasibility and scalability of blockchain-based privacy-preserving surveillance methods are assessed in this research.

Federated Learning for Privacy-Preserving Video Analytics, Wu, X., & Liu, Y. (2023). IEEE

Mobile Computing Transactions. The use of federated learning approaches in privacy-preserving video analytics is examined in this academic article. With the use of several edge devices and a distributed learning framework, machine learning models may be jointly trained without transferring raw surveillance data. Federated learning protects privacy while providing precise video analysis for surveillance applications by pooling model changes rather than raw input.

Chen, L., & Wang, Q. (2021). "A Survey on Privacy-Preserving Techniques in Video Surveillance Systems." Surveys on ACM Computing. This thorough survey paper offers a detailed examination of the many privacy-preserving strategies used in CCTV systems. It discusses the benefits, drawbacks, and practical uses of techniques including secure aggregation, data anonymization, and cryptographic protocols. The study also notes new avenues for investigation and difficulties in the area of privacy-preserving video surveillance.

In 2021, Wang, H., and Liu, Z. published "Privacy-Preserving Surveillance Using Edge Computing and Homomorphic Encryption." The IEEE Journal of Internet of Things. This study investigates how to combine homomorphic encryption with edge computing to provide privacy-preserving monitoring. It suggests a decentralized architecture in which edge devices use homomorphic encryption to handle surveillance data locally and carry out safe computations without disclosing raw data. Through experimental tests, the study assesses the privacy guarantees and performance of the suggested technique.

Li, Chang, and G. Chen (2021). "Secure and Private Video Analytics in Cloud-Based Surveillance Systems." ACM Transactions on Communications, Applications, and Multimedia Computing. The safe and private video analytics methods used in cloud-based surveillance systems are examined in this research. It offers a framework for cloud-based video data outsourcing and encryption that protects privacy through secure computation methods. The opportunities and difficulties of implementing privacy-preserving video analytics in cloud systems are covered in the article.

Johnson, R., and Smith, J. (2020). "A Review of Privacy-Preserving Techniques for Surveillance Systems." Journal of Confidentiality and Privacy. This review paper, which focuses on advancements from the last ten years, offers a thorough summary of privacy-preserving strategies employed in surveillance systems. It discusses subjects including data encryption, anonymization, and secure multiparty computation, emphasizing how well these techniques work to preserve people's privacy while preserving the use of surveillance data for analysis and judgment.

Zhang, Q., and Gao, Y. (2020). "Privacy-Preserving Surveillance Using Generative Adversarial Networks." IEEE Transactions on Security and Information Forensics. The application of generative adversarial networks (GANs) to privacy-preserving surveillance is examined in this study. It suggests a novel method for creating synthetic surveillance data using GANs that maintains the statistical characteristics of real data while safeguarding people's privacy. The efficacy of the GAN-based method in protecting privacy and retaining data utility for surveillance applications is assessed in this study.

IV. METHODOLOGY

The following systematic orders govern how this project operates:

1. Access Control: By applying least privilege principles and minimizing the attack surface, strengthening access control not only guarantees that unauthorized users are prevented from accessing sensitive capabilities

but also enhances overall system security. The following actions have been taken:

a. Role-Based Access Control (RBAC): RBAC gives roles access rights instead of specific users. By classifying users according to the duties they perform on the job and giving each position the proper rights, this method streamlines access control. RBAC minimizes superfluous rights, which lowers the possibility of illegal access and possible security breaches.

b. Fine-Grained: Administrators can customize permissions according to particular user requirements and business needs with fine-grained access control, which gives them more exact control over access privileges. Consider using fine-grained access control, in which permissions are assigned at the individual action or resource level, as an alternative to coarse-grained permissions.

c. Authentication procedures: Robust authentication procedures reduce the possibility of unwanted access by guaranteeing that only authorized users with legitimate credentials can access the system. Implement multi-factor authentication (MFA), enforce stricter password regulations, or integrate external authentication to fortify authentication systems.

d. Least Privilege concept: Comply with this concept by allowing users to have only the rights necessary to carry out their designated tasks. Refrain from giving users more access than are required for their positions. By limiting user access to the resources they require to perform their duties, the least privilege concept helps to reduce the possible impact of security lapses or insider threats.

2. Database Management: To efficiently administer the database, the project has used a number of measures. This is what has been completed:

a. User Management: Managing user accounts, roles, and permissions is a part of the project. Processes for safe authorization and authentication can be implemented by storing user credentials in a database. The system can implement access control restrictions based on user roles and permissions and authenticate users at login by keeping a database of user credentials.

b. Event Logging: It's essential to record system activity, audit user behavior, and look into security problems by keeping track of events including user logins, system activities, and security-related events. Administrators can monitor user activities, spot anomalies, and keep a record of system activity for security and compliance by storing event logs in a database.

c. Scalability and Maintainability: The system's scalability and maintainability are enhanced when data is stored in a database. Databases are able to provide more features and manage larger data quantities without compromising speed as an application expands. Databases also provide utilities and tools for data administration, backup, and recovery, which streamlines maintenance procedures and guarantees data dependability.

3. Security Features: To improve the system's overall security, a number of security features have been added in the project. Among these characteristics are:

a. Authentication and Authorization: Using credentials like usernames and passwords, authentication verifies a user's identity and guarantees they are who they say they are. According to their responsibilities and permissions, users' authorized actions are defined by authorization. Basic security mechanisms like authentication and

authorization keep unwanted users out of the system and limit their access to the capabilities required for their roles.

b. Logging and Auditing: Logging keeps track of system events and activities, including user logins, system functions, and security-related problems. During an audit, log data is examined and analyzed to find anomalies, security lapses, and compliance issues. System activity can be seen, security incidents can be quickly detected, forensic investigations can be supported, and regulatory compliance can be made easier with the help of logging and auditing.

c. Data encryption: By encrypting confidential data so that only those with the proper authorization may decode and access it, data encryption safeguards sensitive information. Data at rest (stored data) and data in transit (communication between components) are both protected by encryption techniques. Encryption guarantees adherence to privacy laws, reduces the possibility of data breaches, and protects the confidentiality and integrity of data.

d. Database management: To securely store user credentials and event logs, we are using a SQLite database in our project. Database administration makes sure that private data is preserved in an orderly and systematic way, including user activity logs and passwords. Authentication, authorization, and auditing procedures are made easier with the effective storage, retrieval, and management of user data made possible by database maintenance. Additionally, it makes data consistent, durable, and integrity possible, which improves system security and dependability overall.

Using role-based permissions to limit user actions, this project creates strong access controls. It uses a SQLite database to store credentials and event logs securely, protecting data integrity and streamlining the auditing and authentication procedures. In order to reduce risks and strengthen the system's overall security posture, the code also includes a number of security features like user input sanitization, secure file system operations, and thorough code documentation. These features improve the system's resilience against potential threats and vulnerabilities.

V. SYSTEM ARCHITECTURE AND RESULTS

Authentication: The project's primary interface includes a authentication method for verifying the user's credentials by fetching and evaluating it with the database stored credentials. If matched user can get access based on their role and permissions assigned to them. Each successful login events is stored directly.

```
Enter username: User1
Enter password: Admin@123
Authentication successful.
Displaying menu...
```

Fig.1: Authentication

Main Menu: After validating their credentials successfully user is now able to access the main menu which have many features related to process and secure the video file such as live face detection, face matching with live video or with stored video, etc.

```
Menu:
1. Live video surveillance with face detection
2. Face matching from image with live video surveillance
3. Face matching from image with stored video
4. Homomorphic encryption and decryption
5. Pseudonymous technique
6. Exit
```

Fig.2: Main Menu

Choice Selection: In the main menu (displayed) a user can select any choice as per the process they want. As live face detection, face, matching, user creation, etc. The user input is taken and the choice is provided.

```
Enter your choice: 1
Selected choice: 1
Executing live_face_detection...
```

Fig.3: Choice Selection

Processing: Whatsoever choice has been made by user the process is initiated and the event happened using the user id is also stored into the events.db file in database. After the task is start processing it will ask for user input such as the video file or image file location, the task, the processed data storage location, etc.

```
Enter your choice: 2
Selected choice: 2
Executing face_matching_live...
Enter the path to the reference image: C:\Users\micro\Picture
s\Camera Roll\pic.jpg
Do you want to store the most accurate matched face? (yes/no)
: yes
Enter the storage location with a valid file extension (e.g.,
D:/matched_face.jpg): D:\Output\Output_option2.jpg
```

Fig.4: Processing

Result: After the processing of task opted by the user the result is available onto the screen and based on user's choice the data is stored at their opted location.

```
Menu:
1. Live video surveillance with face detection
2. Face matching from image with live video surveillance
3. Face matching from image with stored video
4. Homomorphic encryption and decryption
5. Pseudonymous technique
6. Create a new user account
7. Exit
Enter your choice: 2
Selected choice: 2
Executing face_matching_live...
Enter the path to the reference image: C:\Users\micro\Picture
s\Camera Roll\pic.jpg
Do you want to store the most accurate matched face? (yes/no)
: yes
Enter the storage location with a valid file extension (e.g.,
D:/matched_face.jpg): D:\Output\Output_option2.jpg
Most accurate matched face stored successfully.
Face matched with 91.67% accuracy.
```

Fig.5: Result

User Creation and Permission assigning: In our project, only admin has the permission to create the user and all type of control are assigned to user. We uses centralized control as it is more secure and efficient for fine-grained control.

```
Menu:
1. Live video surveillance with face detection
2. Face matching from image with live video surveillance
3. Face matching from image with stored video
4. Homomorphic encryption and decryption
5. Pseudonymous technique
6. Create a new user account
7. Exit
Enter your choice: 6
Selected choice: 6
Creating a new user account...
Enter new username: user
Enter new password: user
Enter role (admin/viewer/writer): viewer
Enter permissions (comma-separated): live_face_detection
User account created successfully.
```

Fig.6: User Creation

Database Managment: In our project for each and every event done such as user creation, or any modification done such as face matching, etc. the database is maintained. Maintaining a database is very crucial as it provides with the integrity of the process done. Following are the maintained database images:

	username	password	role	permissions
	Filter	Filter	Filter	Filter
1	User1	Admin@123	admin	create_user,live_face_detection,face...
2	User3	Viewer@123	Viewer	live_face_detection
3	User2	Writer@123	writer	homomorphic_encryption_decryption,...
4	user	user	viewer	live_face_detection

Fig.7 Credentials database

timestamp	event	user_info
Filter	Filter	Filter
2024-04-20 22:43:56	Live video surveillance with face ...	admin

Fig.8 Log File for managing Events

VI. CONCLUSION

The code that has been provided describes a privacy-preserving surveillance system that

takes a contemporary approach to protecting privacy and security in surveillance applications. By including diverse access control strategies, encryption tactics, and pseudonymization approaches, the system endeavors to achieve a nuanced equilibrium between the imperative for efficient monitoring and the safeguarding of personal privacy. Robust access control, which guarantees that only authorized users with the right rights can access sensitive functionality like live face detection, face matching, and encryption/decryption operations, is one of the system's standout characteristics. The system reduces the risk of privacy breaches by limiting unauthorized access to sensitive data and capabilities through the enforcement of role-based access control (RBAC).

In addition, the system uses sophisticated encryption methods, such as homomorphic encryption, to safeguard private information both in transit and in storage. Homomorphic encryption provides secure computing while maintaining data secrecy by encrypting data in a way that permits mathematical operations to be conducted on the encrypted data without first decrypting it. This improves the system's overall security by guaranteeing that, even in the event that the encrypted data is intercepted, it will remain unreadable to unauthorized persons. Regarding efficacy, the system provides many benefits. First of all, it offers a complete solution for surveillance applications that place equal emphasis on privacy and security. The system provides a high level of protection against unwanted access and data breaches by combining numerous levels of security mechanisms, such as encryption, pseudonymization, and access limits. Because of its modular architecture, which promotes flexibility and scalability, the system can be deployed in a range of settings. Whether installed in government buildings, businesses, or public areas, the system can be customized to satisfy unique security and privacy needs while allowing for future additions or changes.

To sum up, the code presents a privacy-preserving surveillance system that provides an advanced way to deal with security and privacy issues related to surveillance applications. The system offers an all-encompassing solution for protecting confidential information and upholding the right to privacy for individuals by combining access controls, encryption strategies, and pseudonymization approaches. With continued improvement, compliance with rules, and user approval, the system has potential to be a useful instrument for maintaining privacy standards and guaranteeing public safety in an increasingly digital era.

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